Extrasolar Planets, Today and Tomorrow
ASP Conference Series, Vol. xxx, 2004
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Strong Limits on the Infrared Spectrum of HD 209458 b Near 2.2 μm

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Abstract. We present a brief summary of observations of the transiting extrasolar planet, HD 209458 b, designed to detect the secondary eclipse. We employ the method of 'occultation spectroscopy', which searches in combined light (star and planet) for the disappearance and reappearance of weak infrared spectral features due to the planet as it passes behind the star and reappears. We have searched for a continuum peak near 2.2 μm (defined by CO and H_2O absorption bands), as predicted by some models of the planetary atmosphere to be $\sim 6 \times 10^{-4}$ of the stellar flux, but no such peak is detected at a level of $\sim 3 \times 10^{-4}$ of the stellar flux. Our results represent the strongest limits on the infrared spectrum of the planet to date and carry significant implications for understanding the planetary atmosphere.

1. Background

Our observations cover two predicted secondary eclipse events, and we obtained 1036 individual spectra of the HD 209458 system using the SpeX instrument at the NASA IRTF in September 2001. Our spectra extend from 1.9 to 4.2 μm with a resolution ($\lambda/\Delta\lambda$) of 1500. A summary of the method of occultation spectrosocpy, as well as the details of the data analysis, can be found in Richardson, Deming, & Seager (2003).

2. Results and Discussion

The final difference spectrum, shown in Figure 1, represents the average candidate planetary spectrum, as calculated from the 'in-eclipse' minus the 'out-of-eclipse' spectra from the two nights during which a secondary eclipse was predicted to occur. The average spectrum represents data from 550 individual spectra of HD 209458, as well as an equal number of spectra of the comparison star HD 210483. The comparison star was used in our analysis to remove variability due to changes in the terrestrial atmsophere and to normalize the data to the stellar flux density. Also shown in Figure 1 is the baseline model for

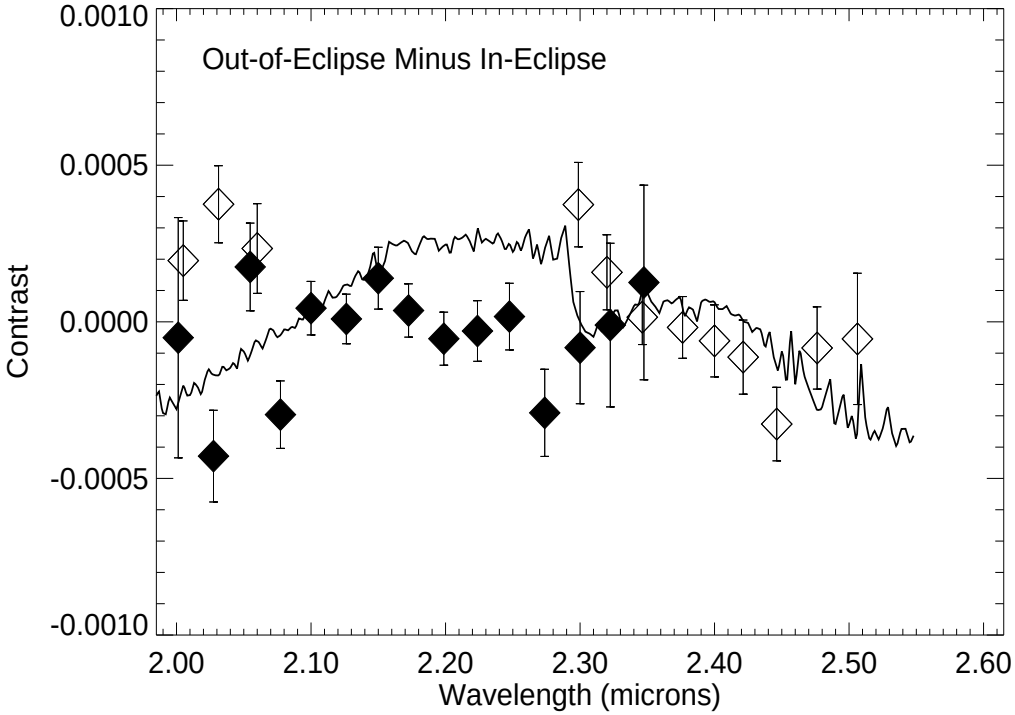

Figure 1. Final candidate planetary spectrum (symbols). Solid line represents the baseline model for HD 209458 b as caluclated by Sudarsky, Burrows, & Hubeny (2003). The offset between the model and the data is not important, since we are comparing the shapes of the two spectra; thus, the mean has been subtracted from the data and model, respectively, for plotting purposes.

HD 204958 b calculated by Sudarsky, Burrows, & Hubeny (2003), which exhibits a peak near 2.2 μm. A least-squares analysis indicates this peak is not present in the candidate planetary spectrum as derived from the data.

We believe this result has significant implications for the structure of the planetary atmosphere. In particular, some models that assume the stellar irradiation is re-radiated entirely on the sub-stellar hemisphere predict this flux peak, which is inconsistent with our observations. Several physical mechanisms can improve agreement with our observations, including the re-distribution of heat by global circulation, a nearly isothermal atmosphere, and/or the presence of a high cloud.

References

Richardson, L. J., Deming, D., & Seager, S. 2003, ApJ, 597, 581

Sudarksy, S., Burrows, A., & Hubeny, I. 2003, ApJ, 588, 1121